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BRIEFING

ON

SUPERSONIC INTERCONTINENTAL BOMBING

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This material contains the results of analyses performed by Operations Analysts. It does not necessarily express USAF policy.

1 August 1949

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SUPERSONIC INTERCONTINENTAL BOMBING

SUMMARY

This report presents a new weapons system, capable of delivering an atomic bomb on the Russian industrial area within a radius of 4500 nautical miles from bases within the continental United States, in a non-stop flight with speeds not less than M = .9 over enemy territory, and with a 1000 nautical mile supersonic burst over the target area.

Such performance, highly desirable for strategic bombing operations, cannot be achieved at present in a single aircraft. As aircraft speeds, range, and other performance characteristics improve thru technical development, it may seem that in the future one aircraft could provide an adequate compromise of speed and range for a strategic bomber. However, at any stage of the art, as long as fuel constitutes a high per cent of the gross weight, i.e., with chemical fuels, the interceptor's speed advantage will remain, assuming equal technology on both sides. Thus some operational device is required that will supplement the bomber's performance and allow its speed to approach that of the interceptor.

The weapons system presented here is designed to fulfill this requirement. This system is based principally on two concepts:

1. Wing-tip linking of aircraft to provide maximum efficiency in cruising across undefended area to the enemy perimeter.

2. A composite aircraft, where a small supersonic bomber is carried as a pod to the enemy perimeter, released to penetrate at high speed, bomb, and return for attachment and transport home.

THE PROBLEM

The Air Force problem today is to be able to conduct strategic bombing and reconnaissance operations from bases in the continental United States against targets on other continents requiring range of the order of 10,000 statute miles. At the same time these bombers must be able to cope with enemy fighters, already pressing supersonic speeds. Bomber defense has many facets, but high speed will always be among the best.

Yet long range and high speed in an aircraft are not compatible at the present time. Maximum range and maximum speed are fundamentally opposing in their demands upon the energy available from any chemical fuel.

A Rand bomber study* concludes that an attainment of 4340 nautical miles combat radius is very questionable for a turbojet powered bomber, and obviously the maximum range can be obtained only at the most efficient cruising speed, about M = .8 for a jet aircraft.

A fighter built for short-range interception will always have a speed advantage over an aircraft that must come in from a long range. Hence the specific problem is how to provide in an aircraft system a combination of long range and supersonic speed over enemy territory.

PRESENT STATE OF THE ART

Certain presently available aircraft and propulsion systems can fly a very long range at low subsonic speeds, while other aircraft and propulsion systems can fly at supersonic speeds but for a very short range. At the present time the simultaneous combination of high speed and long range appears incompatible from the fundamental standpoint that a greater rate of expenditure of energy per mile is required as the speed increases.

Also the prospects appear remote of providing in a single aircraft a sufficient range of speeds so that such an aircraft could fly slowly and efficiently, yet also be capable of supersonic speeds. This conclusion stems largely from the limited speed characteristics of different propulsion systems, as illustrated in Exhibit A.

* No. D-339, 30 December 1948

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RELATIVE RANGE VERSUS SPEED

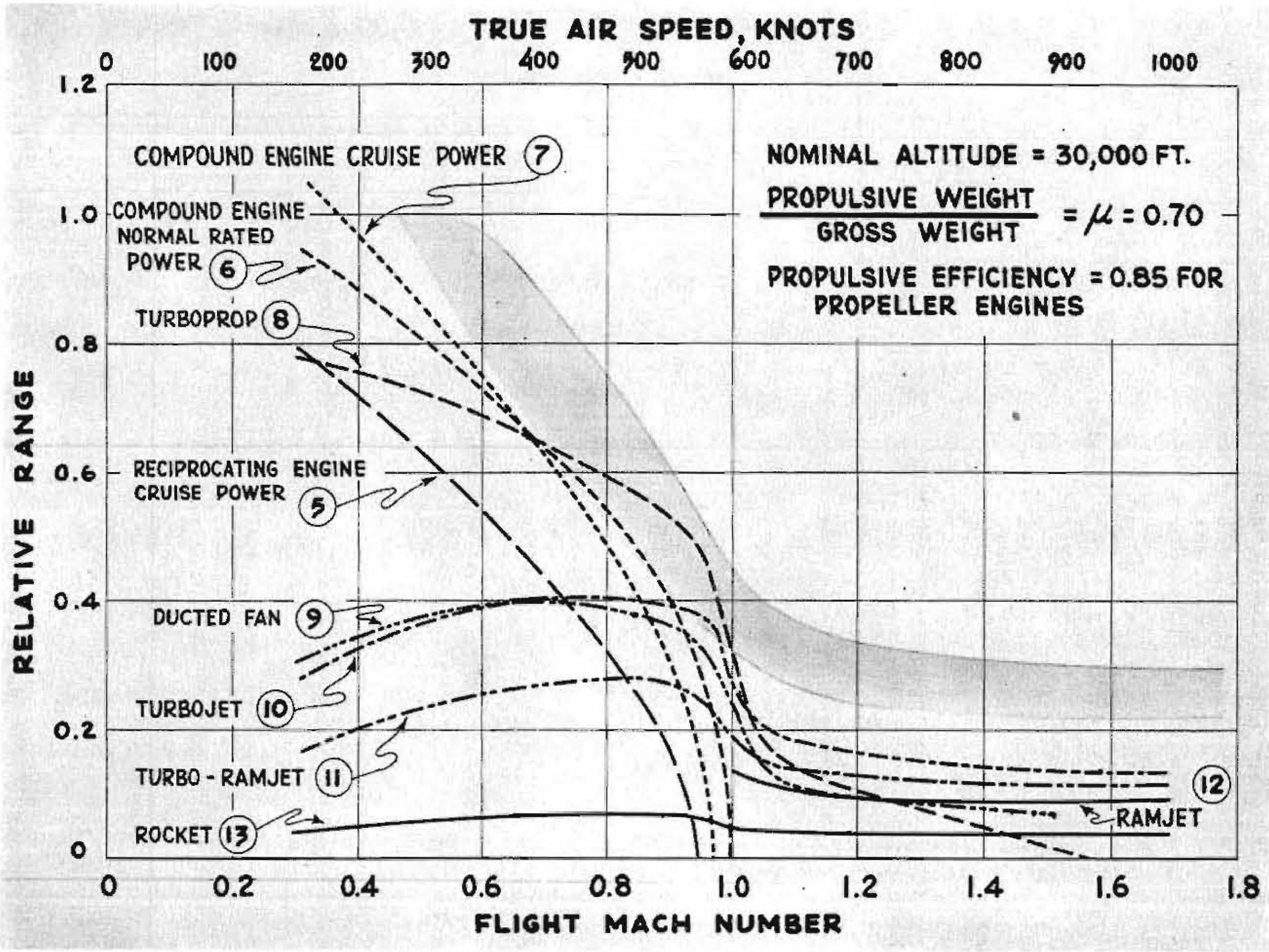

EXHIBIT A

THIS CHART* SHOWS THAT A PROPULSION SYSTEM THAT CAN PROVIDE MAXIMUM RANGE CANNOT FLY SUPERSONIC, AND CONVERSELY, THAT A PROPULSION SYSTEM THAT CAN FLY SUPERSONIC CANNOT FLY LONG RANGE. A MORE FLEXIBLE PROPULSION SYSTEM MIGHT ALLEVIATE THIS DEFICIENCY, BUT NONE IS IN SIGHT. THE ENVELOPE OF THESE CURVES ALSO ILLUSTRATES THAT GREATER RANGE CAN BE OBTAINED BY FLYING SLOWLY, AND TO A LARGE EXTENT THIS IS FUNDAMENTAL.

** BASED ON RAND REPORT NO. R-114, AUGUST 13, 1948, FIG 9a, P. 29, ENVELOPE BASED ON SILVERSTEIN, RESEARCH ON AIRCRAFT PROPULSION SYSTEMS, JOURNAL OF THE INSTITUTE OF THE AERONAUTICAL SCIENCES, APRIL 1949, FIG 57, PAGE 221.*

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PROPOSED SOLUTION

Since it is apparent that maximum range can be obtained only by flying slowly to the enemy perimeter, and since it appears impossible to obtain such maximum range and also supersonic speeds in a single aircraft, it is proposed to use two aircraft.

Thus instead of a single compromise aircraft, two specialized aircraft would be used. The supersonic bomber would be transported to the enemy perimenter by the efficient long-range aircraft. The most feasible way to transport the supersonic aircraft would appear to be a semi-external bomb bay pod, thus providing a composite aircraft.

Aircraft can obtain maximum efficiency in cruising by wing-tip linking. Such a linked assembly, employing three B-36 carrier aircraft linked at their wing tips, with three Delta wing supersonic bombers attached as pods, is shown in Exhibits B and C. All aircraft would take off separately, the carriers linking at their wing tips in flight, then assembling the supersonic bombers as pods by using an attachment boom similar to that under development for refueling.

PERFORMANCE CALCULATIONS

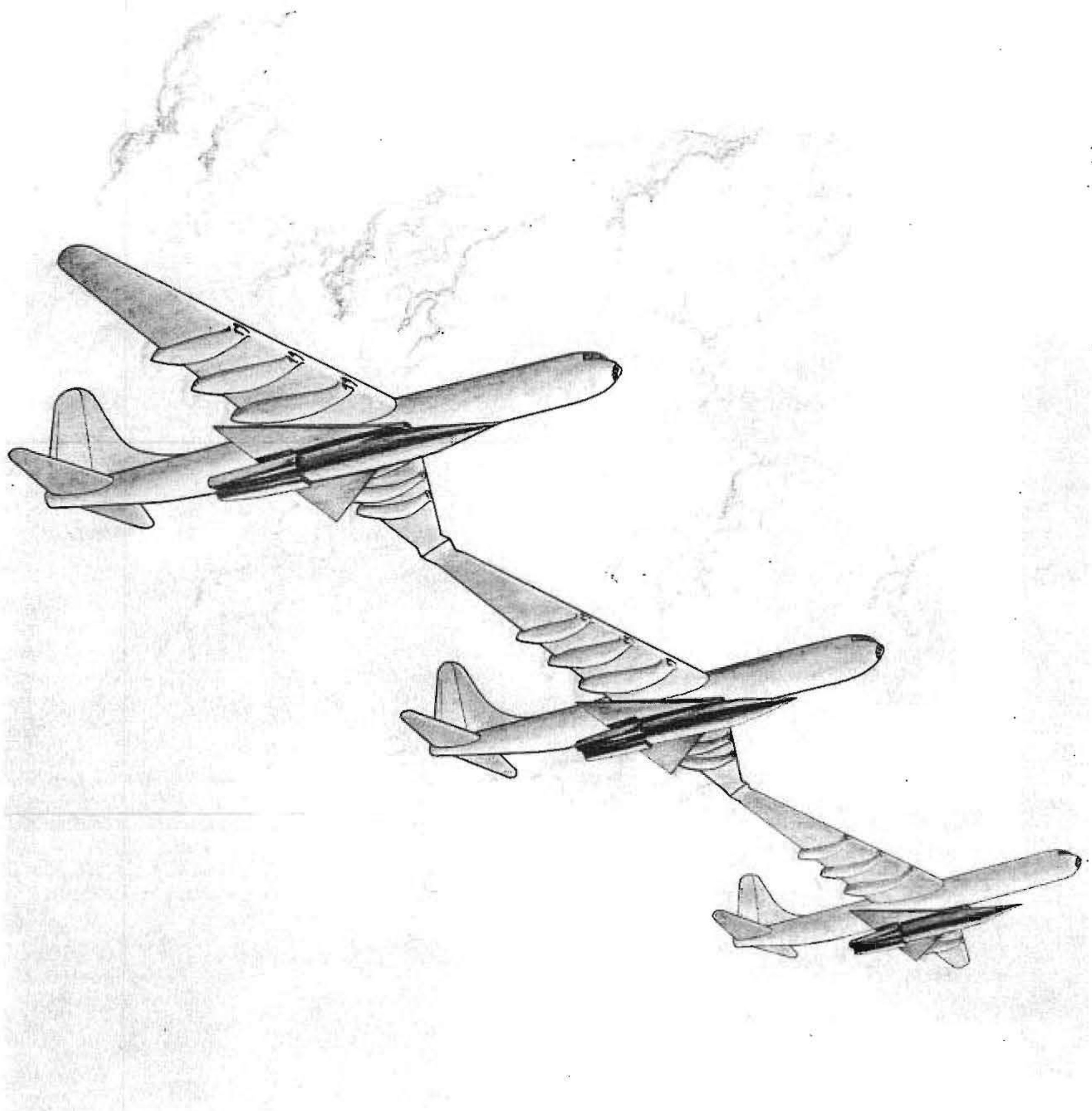
Basic data employed is that for the B-36D and a Convair design study on a Delta wing supersonic bomber. Range is calculated by Breguet's equation:

$$R = E \times \frac{L}{D} \times \text{LOG} \frac{W_i}{W_f}$$

The L/D for a linked series is based on its effective aspect ratio. This is calculated by a method taking into account the non-uniformity of the downwash caused by the taper ratio, sweep, and irregularities in a plan form consisting of a series of linked B-36 wings. The L/D of a single B-36D is 20 and the L/D for a linked series of these aircraft is 27.5. When the bomber's wing is carrying no weight, the L/D of the linked assembly carrying three supersonic bombers as pods is 24.5 allowing a conservative interference drag of 10% on both the B-36 and the Delta.

Since range is proportional to L/D, these values show directly the gain afforded by linking, and also the efficiency of transporting the Delta bomber as compared to its own subsonic L/D of 9.8. When it flies alone, the Delta bomber suffers a further range penalty due to its less efficient turbojet propulsive system.

The performance calculations are shown in Exhibit D.



COMPOSITE LINKED AIRCRAFT ASSEMBLY

EXHIBIT 'B'

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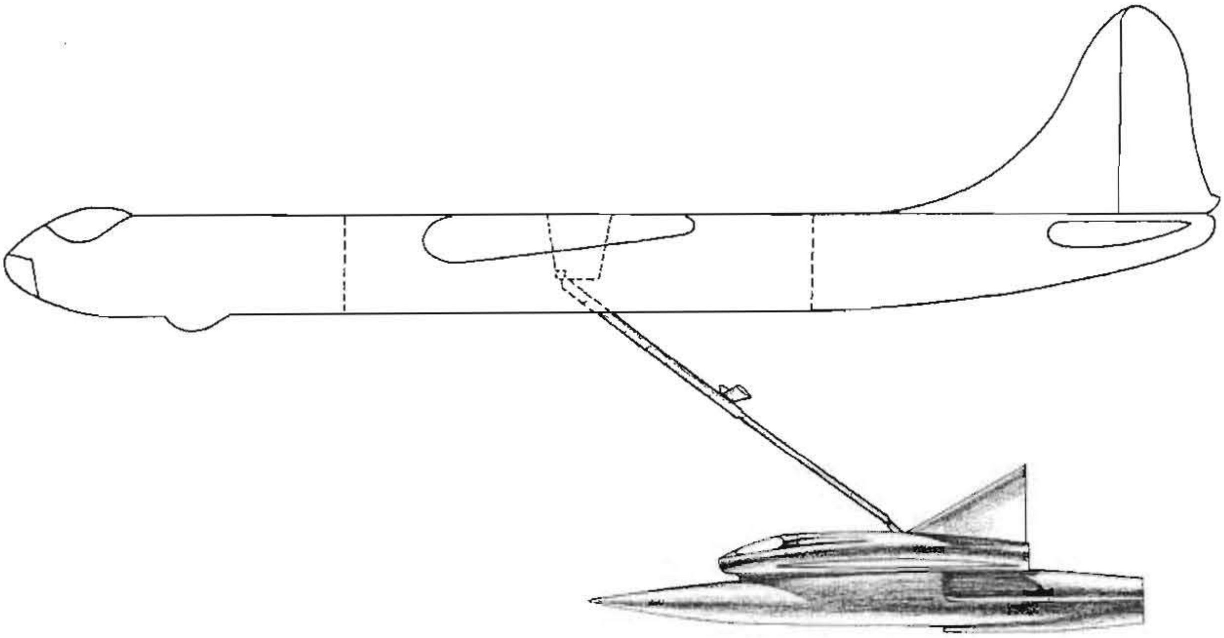
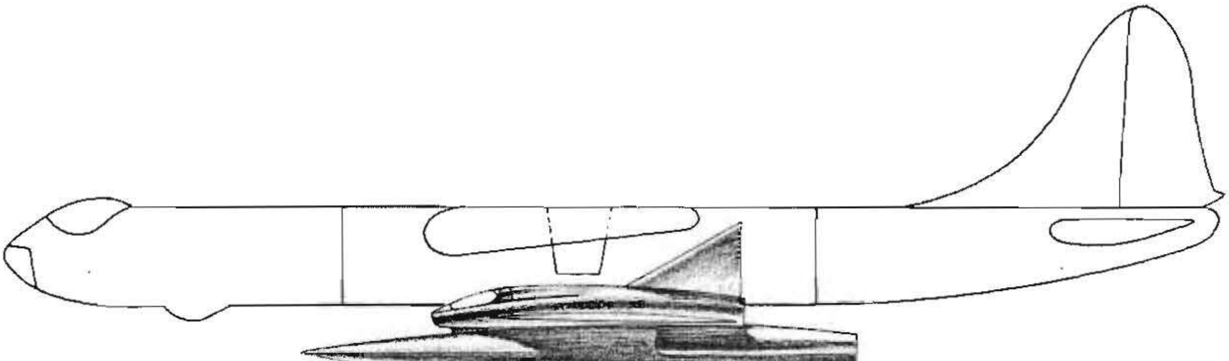


ATTACHMENT OF BOMBER BY FLYING BOOM



BOMBER IN POD POSITION

EXHIBIT 'C'

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EXHIBIT D

MISSION CALCULATIONS

B-36-D CARRIERS

Phase	B-36 Operation	Hours (1)	Cumulative Mission Hours (2)	Knots Average (3)	Nautical Miles (4)	Cumulative Nautical Mission Miles (5)	Altitude Feet (6)	Initial Weight W_i (7)	Initial Weight of Delta when Carried as B-36 Pod (7A)	Total Initial Assembly Weight (7B)	Initial Weight in Excess of 357,500 lbs. to be carried by Delta Wing (7C)	R-4360-41 Engines-C-Average Engine Spec + 5% (8)	L/D (9)	$\eta = .84;\ \frac{863.5}{1.15} \times \eta = 630$ (10)	Log $\frac{W_i}{W_f}$ = $\frac{(4)x(8)}{(10)x(9)}$ (11)	Anti-log of (11) (12)	$W_f = \frac{(7)}{(12)}$ (13)	Pounds Fuel Used by 43602 (14)	Average Weight (15)	Fuel Transferred from B-36 to Delta at end of this Phase (16)	Four T6 190 B Jets on Each B-36: Minutes Operated (17)	Four T6 190 B Jets on Each B-36: Pounds Fuel Consumed (18)	Remaining Weight Pounds (19)
1	Starting, Warm Up, Take Off Separately, Climb to 10,000 Feet	.183	.183	180	33	33		357,500				.746						4,151			(4) 16	6,171	347,178
2	Link B-36's, Cruise at 184 Knots	5.98	6.163	184	1100	1133	10,000	347,178				.46	27.5		.0292	1.07			335,500		0		324,000
3	Cruise at 258 Knots, Attach Deltas as B-36 Pods	.5	6.563	258	-	1133	10,000	324,000				.746						5,930			(2) 30	1,950	316,120
4	Cruise as Assembly, Deltas Carrying Weight Over 357,500 Pounds	5.08	11.743	185	941	2074	10,000	316,120	67,700	383,820	26,320	.483	23.4		.031	1.073	357,500*						357,500*
5	Cruise as Assembly, Deltas Carrying no Weight. Fuel is Transferred. Crews Reenter Deltas	1.96	13.703	180	353	2427	10,000	289,800	67,700	357,500	0	.472	24.2		.01091	1.025	349,000*						349,000*
6	Accelerate to 243 Knots and Release Deltas	.29	13.993	243	73	2500	10,000	239,000	110,000	349,000	0	.746						3,410			0		235,590
7 A	Loiter Away from Coast	6.33	20.323	148	936		10,000	235,590				.46	27.5		.0249	1.059	222,300		227,600		0		222,300
8	Climb to 40,000 Feet	.5	20,823	184	92			222,300				.746						5,930	219,300		0		216,370
P	Attach Deltas as B-36 Pods	.405	21.228	330	-		40,000	216,370				.746						3,990			0		212,380
8	Cruise as Assembly, Deltas Carrying No Weight	11.4	32.628	219	2500	5000	40,000	212,380	20,135	232,515	0	.483	24.6		.0780	1.197	194,300		213,407		0		194,300*
9	Cast off Deltas with One Hour's Fuel			219	-			171,165	23,135	194,300													
10	Land B-36's with 5% Fuel Reserve																		8,633				162,532

* Includes weight of Delta

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EXHIBIT D

MISSION CALCULATIONS

DELTA BOMBERS

Phase	Delta Operation	Hours (20)	Cumulative Hours per Operation (21)	Knots Average (22)	Nautical Miles (23)	Cumulative Nautical Miles per Operation (24)	Altitude Feet (25)	Mach Number Average (26)	Weight at Start (27)	Weight Increment (28)	Initial Weight (29)	Specific Fuel Consumption C' (30)	$\frac{L}{D}$ (31)	Average Thrust Required (32)	Pounds Fuel Consumed (33)	$\text{Log } \frac{W_i}{W_f} = \frac{(23)x(30)}{2.3x(22)x(31)}$ (34)	Anti-log of (34) (35)	$W_f = \frac{(29)}{(35)}$ (36)	Average Weight (37)	Engine Settings (38)
1	Warm up, take off, Accelerate and Climb to 27,500 Feet	.1	.1		35	35		.91			96,260		4.3	22,400	4,000			92,260		
2	Cruise at 550 Knots	2.0	2.1	550	1100	1135	27,500	.93			92,260	1.09	9.8			.0970	1.250	73,800		
3	Descend to 10,000 Feet, Cruise at 258 Knots, Attach Deltas to B-36's	.5	2.6	258	—		10,000	.41			73,800	1.00	5.73			.0378	1.090	67,700		
4	Under Tow-Crew Asleep in B-36																			
5 & 6	Fuel Taken Aboard, Crews Reenter, Start, Warm up, Cast Off at 10,000 Feet 220 Miles from Coast			243			10,000		67,700	+ 42,300	110,000				2,000			108,000		
7A	Nose down 30° Accelerating to 274 Knots Flying Speed in 800 Feet Loss of Altitude Continuing Down to 1000 Feet	.043	.043	261	15						108,000	1.13	10.2			.00207	1.005	107,500		(4) N P
B	Cruise at 1000 Feet Towards Coast	.363	.406	400	145	160	1,000	.61			107,500		10.2	10,600	5,180			102,320		(4) N P
C	60 Miles from Coast Begin Climb at 9000 Feet per Minute to 27,500 Feet	.071	.477	576	41	201		.91			102,320				2,350			99,970		(4) M P
D	Cruise at M= .93	1.933	2.410	550	1062	1263	27,500	.93			99,970	1.05	9.8	9,250	18,810	.0900	1.23	81,160		(1) 85% NRP; (3) 50% NRP
E	Climb to 40,000 Feet	.07	2.480		38	1301					81,160				1,340			79,820		(4) M P
F	Accelerate to M=1.32	.128	2.608		83	1384	40,000				79,820				2,670			77,150		(3) M P, (1) MP + Afterburner
G	Cruise at M=1.37	.220	2.828	785	173	1557	40,000	1.37			77,150				4,515			72,635		(3) NRP (1) MP + Afterburner
H	Cruise at M=1.34	.155	2.983	770	120	1677	40,000	1.34			72,635				2,585			70,050		(4) M P
I	Cruise at M=1.37 Reserve (5%)	.409	3.392	790	323	2000		1.37			70,050				6,590			63,460 61,160		(3) M P, (1) NRP
J	Drop Bomb								61,160	— 6,000	55,160				2,300			55,160		
	RETURNING FROM TARGET																			
K	Cruise At M=1.39	.735	.735	785	576	576	40,000	1.36			55,160				9,995			45,165		(4) NRP
L	Drop Pod								45,165	— 16,810	28,355							28,355		
M	Cruise at M=.94	.360	1.095	541	195	771		.94			28,355				1,265			27,090		(1) M P
N	Cruise at M=.92	1.640	2.735	530	870	1641		.92			27,090				4,560			22,530		(1) NRP
O	Cruise at M=.90	.704	3.439	510	359	2000		.90			22,530				1,650			20,880		(1) 89% NRP
P	Attach to B-36 Reserve (5%)	.405		330				.56			20,880	1.04			745 910			20,135 19,225		(1) 85% NRP
9	Fuel Taken Aboard, Crews Reenter, Start, Warm-up, Cast Off and Land									+ 3,000										

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MISSION

(All speeds are in knots
all distances in nautical miles)

To illustrate the performance which this system can achieve, a specific mission has been planned, operating from Limestone, against a target in the Moscow industrial area. As an alternative, the mission may be based at Fairbanks operating against the same target area.

To accomplish this mission, a radius of 2500 miles is provided for the assembly, with the bombers having a further radius of 2,000 miles after release, a total of 4500 miles radius. The carriers loiter off the enemy coast during the 6.6 hours while the bombers are away.

The carriers are airborne for 33 hours; the bombers, since they take off later, are airborne for 29 hours. While the bombers are carried as pods, their crews may sleep in the carriers, or interchange crews may be provided for the bombing phase.

The operation from Limestone is shown in Exhibit E; from Fairbanks in Exhibit F.

OPERATIONAL PLANNING

All aircraft will take off separately, climb, and assemble when airborne. Cruising to the enemy perimeter is slow, efficient, with little or no chance of interception. The linked assembly flies at 10,000 feet to within 220 miles of the coast, where the bombers are released. Coast line approach tactic is illustrated in Exhibit G.

The bombers descend immediately to 1,000 feet, and approach the coast on the deck at 590 knots. Sixty miles from the coast they climb at an initial rate of 9,000 feet per minute and 590 knots to 27,500 feet, and cruise at 550 knots. This entry tactic and speed should get them by the perimeter screen - then they are lost in a large area.

When 616 miles from the target, approaching the area defense, they climb to 40,000 feet and cruise at M = 1.37, about 785 knots, to target, drop bomb, return for 576 miles at 785 knots, drop bomb pod containing three engines, and cruise at 530 knots back to rendezvous point with carrier for transport home.

The above operation was planned for an extreme radius of 4500 miles, whereas the distance from Limestone to Moscow is only 3593 miles. For such shorter missions the carriers can start home immediately after releasing the bombers, and it would not be necessary for the bombers to drop their three engines.

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EXHIBIT "E"

OPERATIONS BASED ON LIMESTONE

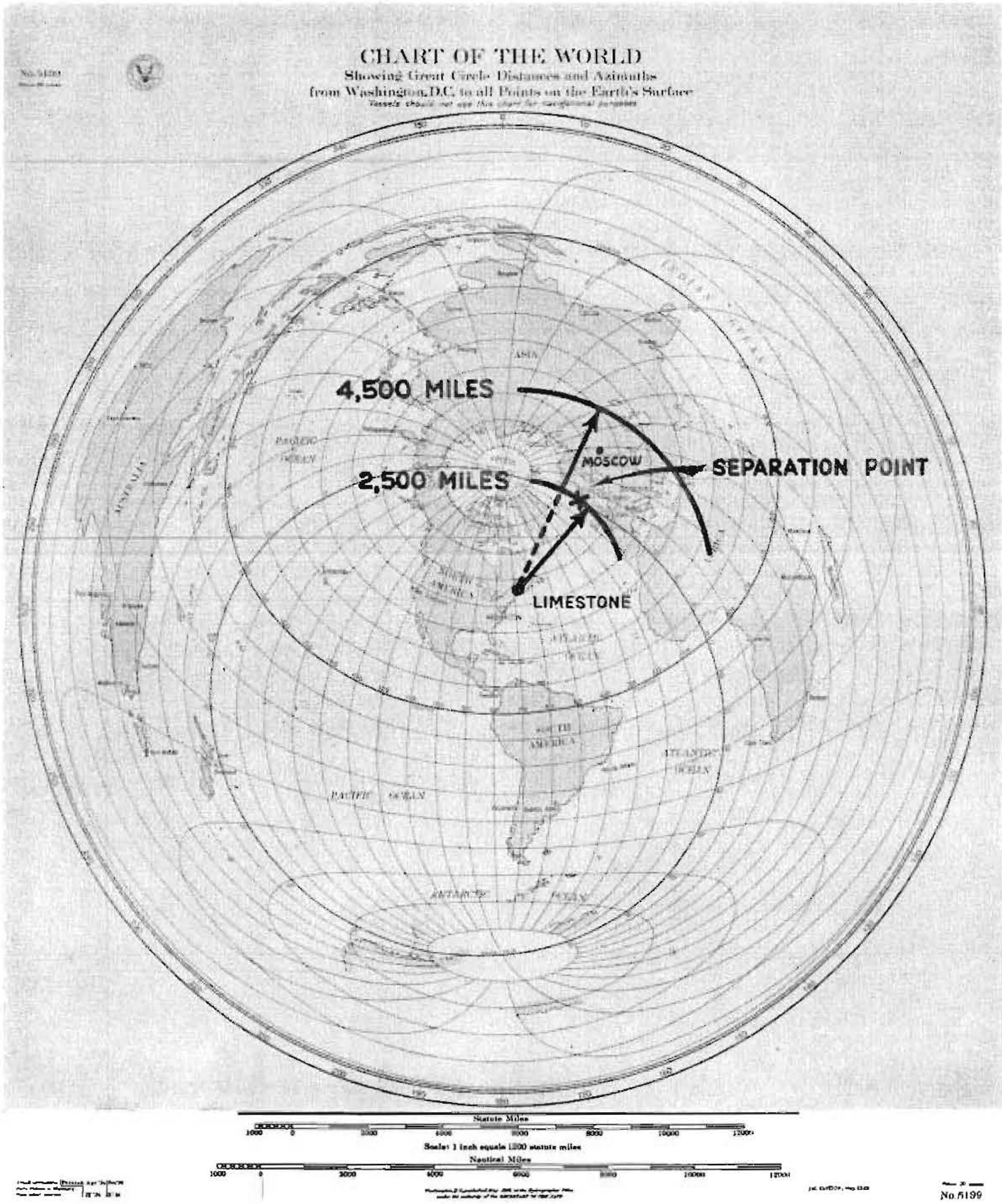

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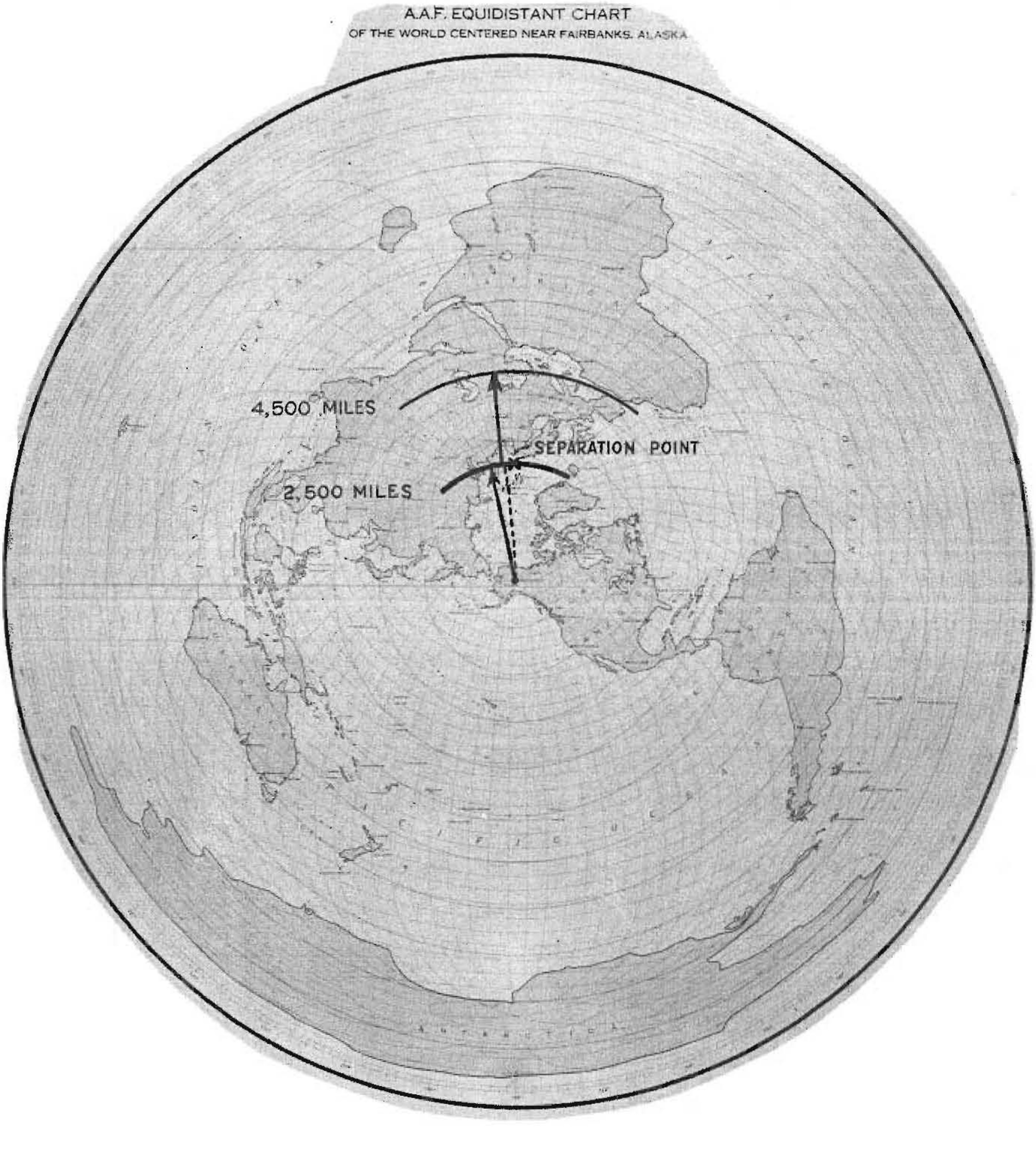
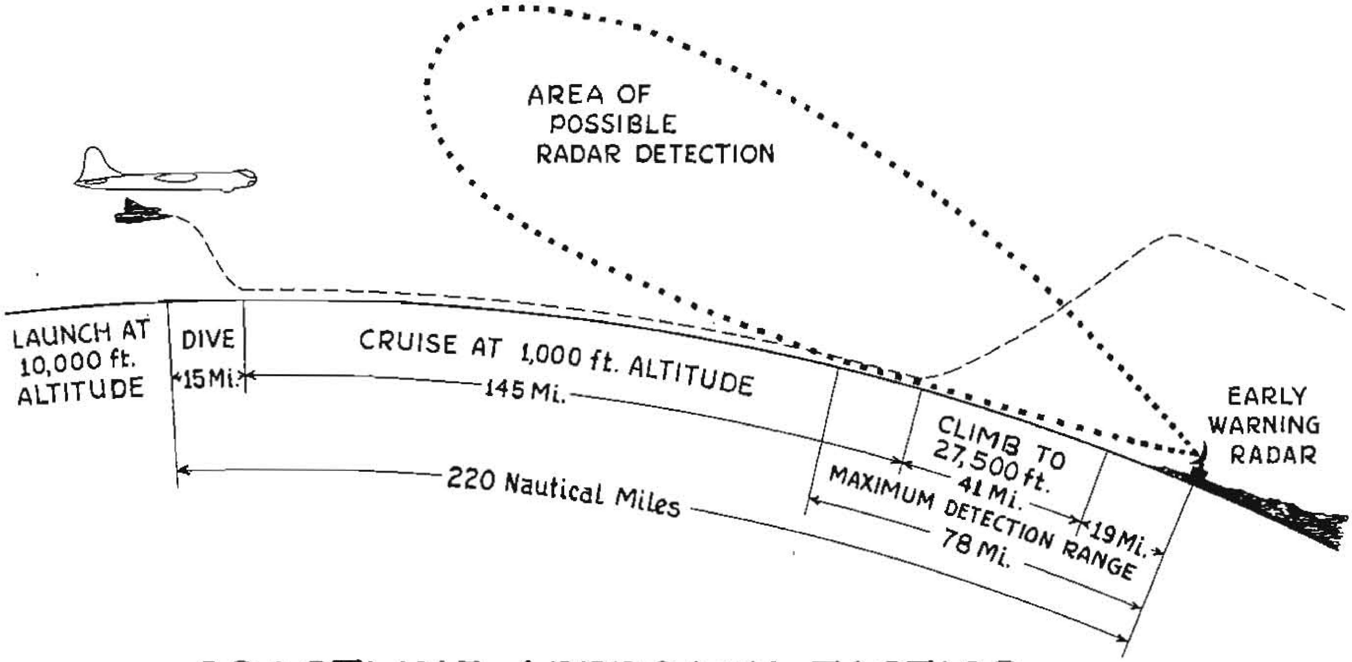
EXHIBIT "F"

OPERATIONS BASED ON FAIRBANKS





COASTLINE APPROACH TACTICS

EXHIBIT 'G'

VARIATIONS

Many variations of this basic system employing composite aircraft will be readily apparent. Such variations may take different outward forms in their operating procedures, but may still utilize the basic principles herein outlined. Certain variations may be desirable for different mission requirements. Other variations may, upon further study, turn out to be more desirable than the initial example presented.

Among such variations are:

1. B-36 take off with Delta already attached as pod, refuel B-36 about 2,000 miles out.
2. Same, but with B-36 taking off light, refueling over base, and again 2,000 miles out.
3. Use only one B-36 and one bomber.
4. Use one B-36 and two bombers on B-36 wing tips.
5. Use other supersonic configuration than the Delta wing.
6. Equip Delta with guns to provide fighter protection for B-36 at return rendezvous.
7. Put two of the Delta's four engines in the return component so it will be a supersonic fighter.
8. Provide the Delta with sufficient range so it can return to its home base alone.

Even as progress appears in the art, the short range interceptor will always retain an advantage. Full utilization of the composite aircraft concept, therefore, appears to offer the only hope yet presented of allowing the bomber's speed to approach that of the interceptor's, assuming equal technology on both sides.

RECOMMENDATIONS

It is recommended that:

1. A requirement be sent to Air Materiel Command for a study of linked composite aircraft assemblies for strategic bombing operations, listing the operational variations that seem most desirable.

2. Air Materiel Command arrange for a contractor to make an engineering study of this system, with particular emphasis on those variations stated as being operationally desirable.